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David Dunlap Observatory
Richmond Hill P.O., Ont.

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Ottawa

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Articles PAGE

The Dimensions of the Galaxy as Defined by the System of Globular Clusters (with Plate XIV) ..... *Helen Sawyer Hogg* 289
Some Advantages of Long Focus Newtonians ..... *E. K. White* 307
Her Majesty's Magnetical and Meteorological Observatory, Toronto (continued from page 278, this volume) ..... *A. D. Thiessen* 311

Review of Publications

Optical Instruments, by Earle B. Brown (*R.K.Y.*)—The Arc Spectrum of Iron, by Henry Norris Russell, Charlotte E. Moore and Dorothy W. Weeks (*F.S.H.*) 320

Notes and Queries

Prisoner of War Liberated (*F.S.H.*)—Eclipse of the Sun of July 9, 1945, at Montreal (*C.A.C.*)—The Mayan Calendar, the "Venus Year" (*C.A.C.*)—The Moon and the Weather (*C.A.C.*) 322

Meetings of the Society

At Toronto—At Windsor 326

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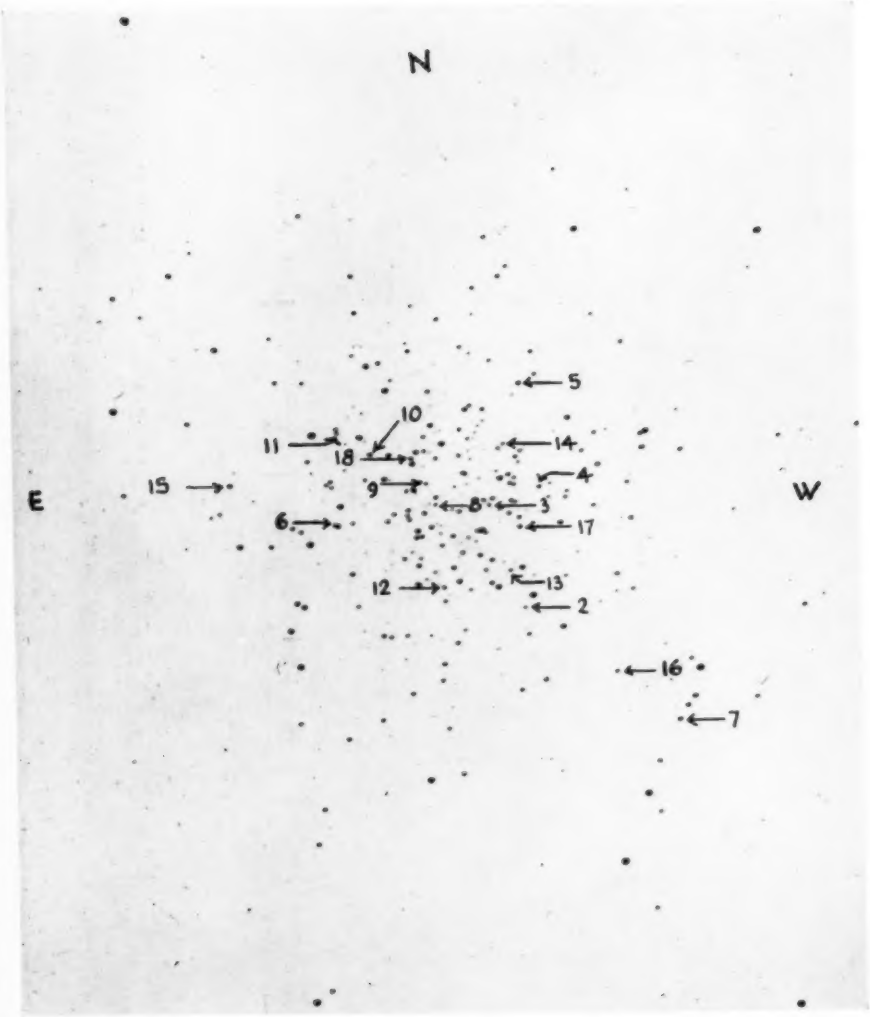

The loose globular cluster NGC 5466, at a distance of 16,000 parsecs above the galactic plane, with variable stars marked. Enlarged from a David Dunlap Observatory plate, exposure 20 min.; scale 1 mm. = 6″.6.

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THE DIMENSIONS OF THE GALAXY AS DEFINED BY THE SYSTEM OF GLOBULAR CLUSTERS*

By HELEN SAWYER HOGG

(With Plate XIV)

IN a consideration of the size of our galaxy, globular clusters appear to be the objects which, at the present time, best indicate its extent. As early as 1909 Perrine[1], and some years later Hinks[2] and Hertzsprung[3], called attention to the curious distribution of globular star-clusters, fringing the galaxy and the Magellanic Clouds. The painstaking investigations of Bailey[4] and the brilliant work of Shapley[5] in deriving the distances of globular clusters showed the importance of these objects as well as the extent of the galactic system. During the intervening years, a great deal of additional information has been obtained in regard to these objects. This paper is therefore a brief stock-taking of our knowledge of these clusters at the present time.

A globular cluster is a beautifully symmetrical aggregation of hundreds of thousands of stars, held together in a cluster by gravitation, and with a total diameter measuring between one and three hundred light-years. If we remember that it takes light less than a quarter of a day to flash from the sun out to our outermost known planet, Pluto, we can see at once that a globular cluster is a system of a sort with which we have no earthly connection.

One reason for the great importance of these clusters as outlines

*The first of three papers constituting a symposium of the Section of Physical Sciences of the Royal Society of Canada at Kingston, Ontario, May 22, 1945.

of our galaxy is that they are found at great distances from the central plane of the Milky Way, that is, the galaxy. Most objects we know are very strongly concentrated towards this plane. And in the plane of the Milky Way lie enormous quantities of obscuring matter of unknown amounts. This obscuring matter vitiates the determination of distances of objects lying within it, since it is very difficult to make proper allowances for its effects. Large numbers of globular clusters are seen projected within it, and for these particular clusters the distances are still not accurately known. Fortunately, however, several dozen clusters lie in regions of the sky practically free from obscuration and recent researches on these objects enable us to get a picture of the overall dimensions of the galaxy.

The galactic plane is a great circle through the heart of the Milky Way. The spherical coordinate north and south of this plane is called galactic latitude, corresponding to latitude on the earth as measured north or south of the equator. We speak of an object as being in high latitude if it is a considerable number of degrees from the central plane of the Milky Way, either north or south.

Dr. Beals will show you that the absorbing material in our galaxy is very strongly concentrated to the plane of the galaxy, and that if we look off into space in a direction making a large angle with that plane we avoid most of the effect of obscuration. To look into the heart of the Milky Way is like trying to look through a sooty window; but to look off into space at right angles to the Milky Way is like looking through a clean window. This is shown very clearly by counts of extra-galactic nebulae—those external galaxies which lie far beyond our own, at distances measured at the present time up to 500 million light-years. If we can see other systems of stars, that is, galaxies, beyond our own, then we know that the absorbing material in our own system is not dimming the light too much. We find that around the galactic poles there is very little dimming of light[6]; indeed long-exposure photographs of the north galactic pole show as many external galaxies on the plate as they show of stars in our own galaxy—a fact staggering in its implications but heartening to any astronomers who feel that they may run out of jobs to do in the future.

But as long-exposure photographs are taken nearer and nearer to the Milky Way, the number of galaxies per square degree falls off constantly, until within about five degrees on either side of the Milky

Way central plane there are none at all. In most of this region masses of obscuring nebulosity are quite obvious in the photographs. As will be shown in the next paper, the general background haze of nebulosity over the sky is relatively uniform down to within a few degrees of the Milky Way, but in these Milky Way clouds there is no uniformity; in fact, we are probably looking through several layers of discrete clouds of nebulosity in many cases. It is therefore very difficult to make allowance for this absorbing material in determining distances of objects close to the Milky Way.

In this paper we will therefore consider the globular clusters as systems, globular clusters around other galaxies, the methods of determining the distances, the outline that they give of our own galaxy, and their possible relation to the elliptical or globular nebulae.

(A) *Globular Clusters.*

At present we recognize 96 globular clusters[7, 8, 9] belonging to our galaxy. Some of these objects are bright enough to be seen with the unaided eye as vague, hazy patches. One-third of these objects are located in the Scorpio-Sagittarius region of the sky, which we believe is the direction to the centre of our Milky Way system. The globular clusters avoid the central plane of the Milky Way. Stebbins and Whitford[10] measure the width of the avoidance zone as 6°.8. This avoidance is almost certainly an optical effect, caused by the heavy obscuring matter in this plane. It is possible that with the help of infra-red photography this number of globular clusters known in our galaxy may be doubled. Many of these clusters were listed by Messier[11] in the 18th century; and most known today were assigned numbers in Dreyer's New General Catalogue[12] in 1888.

In appearance these clusters differ considerably from one another. Some are aggregations of a hundred thousand or more stars, strongly concentrated to the centre. Photographs with even the giant telescopes with exposures sufficiently long to reveal the faint stars blur out the centre. Other globular clusters of a "loose" type appear to contain but a few thousand stars. The clusters have been classified on the basis of appearance by Shapley and Sawyer[13], *I* representing the type concentrated to the centre, and successively higher numerals indicating less and less concentration, with *XII* as the most open. The globular clusters are very different from the

galactic star clusters, which are groups of up to a few hundred stars, scattered along the central plane of the Milky Way.

As well as differing in appearance, globular clusters differ in their total luminosity. Christie has shown a range of five magnitudes in the absolute magnitude[14] of these objects as indicated in figure 1. The most luminous cluster, 47 Tucanæ[15] has an absolute

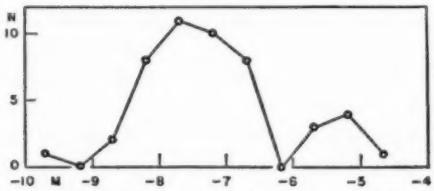

Fig. 1.—Frequency distribution of absolute photographic magnitudes among the globular star clusters. From Christie, Mt. W. Cont. 620, 1940.

magnitude of -10, which is equivalent to one million times the sun's luminosity. The faintest cluster, on the absolute scale is, NGC 7492, which has a total luminosity equivalent to only 10,000 times that of our sun.

The motions of many of these clusters have been determined. The radial velocity, or motion directly toward or away from the sun and earth, has been determined for 26 clusters, largely by the work of Slipher[16] and Edmonson[17] at the Lowell Observatory and Humason[18] at Mount Wilson. The velocities are usually large, up to several hundred kilometres a second. However, these measured velocities reflect the sun's motion of 300 km. per sec. around the centre of the galaxy in Sagittarius; this motion will be discussed by Dr. Pearce in the final paper on this program. If the observed radial velocities of the globular clusters be corrected for the sun's motion, then it is found that they themselves are wheeling around the distant centre with velocities up to 259 km. per sec.; some going clockwise and some counter-clockwise in an approximately circular motion.

More and more knowledge is being acquired in regard to the individual stars which these clusters contain. Spectra of individual stars were obtained by Adams and Pease[19, 20] for the Hercules cluster, Messier 13, ranging from A to G0 with F0 as the mean type. The integrated spectrum of the cluster is known for about 38 objects,

from work by Fath[21] and by Miss Cannon[22]. This spectrum indicates that the brightest stars of these clusters are yellowish or orange giants of type G or K. The colour classes of Stebbins[23], and Whitford[10] indicate an early G on the average. This is in marked contrast to the make-up of stellar population in many galactic clusters in which the brightest stars are commonly of white or blue colour, type O or B.

The importance of the relationship of colour and magnitude, called the colour-magnitude array, in these clusters and in Milky Way star clouds and extra-galactic nebulae, has been known for many years, but has recently been emphasized in papers of Schwarzschild[24], Cuffey[25], and Baade[26]. Stellar populations fall into two groups, group I, in which the brightest stars are of blue types, O and B; and group II, which is lacking in stars of absolute magnitude greater than -1.5. The galactic clusters are examples of group I in our galaxy and the globular of group II. This differentiation into star groups has recently been shown to apply to the nearer extra-galactic nebulae in the resolution into stars by Baade of the nucleus of the Andromeda nebula, —M 31, and its two companions, M 32 and NGC 205.

The slope of the colour-magnitude array diagram for an individual globular cluster appears to determine the characteristics of many of its stars. Some of the globular clusters contain large numbers of variable stars; others contain a mere handful. A total of over 1100 variable stars is known at present[27] in these wonderful objects. The cluster richest in variables, Messier 3, contains about two hundred, while several clusters have been searched without the finding of any variables.

(B) *Globular clusters in extra-galactic systems.*

Before we proceed to a discussion of the distances of globular clusters, it should be noted that they are a fairly common attribute of galaxies in general. Already we know of half a dozen other galaxies around which are scattered globular clusters quite comparable with those around our own galaxy. These other systems include the nearest of the external galaxies, that is the Large[28] and Small[29] Magellanic Clouds, NGC 6822[30], the Andromeda[31] nebula, the Triangulum[32] nebula, the Fornax cluster[33], and the two new el-

liptical nebulae recently resolved by Baade[34], NGC 147 and NGC 185. It is only among the nearer extra-galactic nebulæ of course, that globular clusters could be detected with our present equipment.

(C) *Determination of distances of globular clusters.*

Since globular clusters have such a high absolute luminosity, they can be recognized at great distances in space more readily than individual stars. For this reason they provided Shapley thirty years ago with a key to the great extent of our galaxy. Four methods of attack were used by Shapley in getting the distances.

(1) The most reliable was by the presence of Cepheid variable stars.[35] In 1912 Miss Henrietta Leavitt[36] of the Harvard College Observatory was working on variable stars in the Small Magellanic Cloud, now recognized as the second nearest of the external galaxies. She determined the period for 25 stars and called attention to the fact that the brighter the star appeared the longer was its period of light variation. The periods ranged from 1.2 days to 127 days. This led to a relationship the importance of which was recognized by Hertzsprung[37] and by Shapley[35] and which is now called the period-luminosity relation, illustrated in figure 2. Even in those days it was realized that the Small Magellanic Cloud was so far away that little dispersion in the brightness of the objects it contains could arise from differing distances within the Cloud. Hence a star in the Cloud which appears brighter than another star is absolutely and actually brighter.

There are many classes of variable stars known at present, but only those known as Cepheids (after the type star Delta in the constellation of Cepheus) possess this property. For these remarkable stars it is only necessary to determine the period, whence the absolute magnitude is known at once.

The absolute magnitude of the Cepheids must be determined for the nearby Cepheids from laborious parallax determinations, in order to fix the zero-point of the scale. Once this point is established, the period-luminosity relation may then be applied to any Cepheid whose period and apparent magnitude have been determined. The zero point has been determined by R. E. Wilson[38] from the nearer Cepheids.

Cepheids fall into two broad classes; those with periods over a

day, and those with periods of less than 24 hours. The first group follows the period-luminosity relation in that the longer the period, the brighter the star. Cepheids with periods as long as fifty days are among the most luminous stars known at the present time. For those Cepheids with periods less than a day, a different relation holds. These were discovered in large numbers in the globular clusters

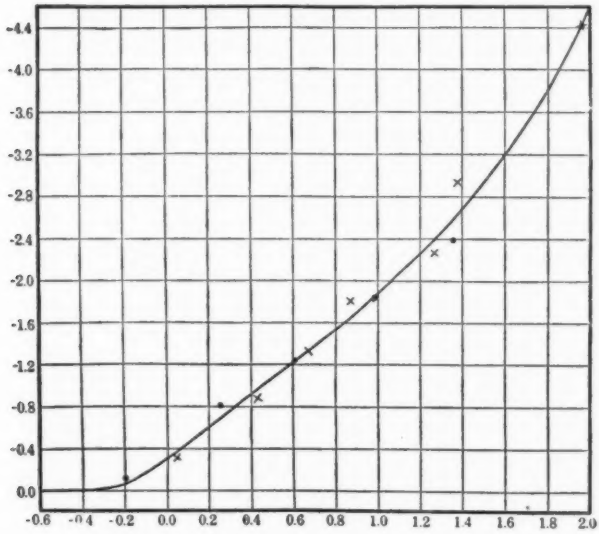

Fig. 2.—The adopted photographic period-luminosity curve. Coordinates are absolute photographic magnitude and logarithm of the period. Dots represent means for intervals of logarithms of periods; crosses, intervals of magnitudes. From Shapley, Star Clusters, p. 135, 1930.

by Prof. Bailey, and hence named "cluster type" variables. These shorter-period variables appear to have a relatively uniform absolute magnitude, regardless of period. Their mean magnitude is taken as 0.0 at the present time.

Most globular clusters which have been investigated thoroughly contain several of either or both of the two types of Cepheids. Of the eleven hundred variables catalogued in globular clusters, about

thirty are the typical Cepheids with periods longer than one day. Fully a thousand would prove to be cluster type; and the remaining ones would fall into the category of other types of variables. Periods have been determined for a considerable fraction of this number.

The best criterion for the distance of a globular cluster therefore, is the presence of Cepheid variables of known period, when by the well-known formula $M = m + 5 + 5 \log p$, the distance, disregarding absorption, is immediately determined.

(2) For globular clusters lacking in variables, or for the many where the variables have not been sufficiently investigated, Shapley[39] used the apparent magnitude of the 25 brightest stars to indicate the cluster's distance, assuming that the absolute magnitude of these was constant from cluster to cluster. In 1929 Shapley and Sawyer[40] showed that the mean absolute magnitude of the 25 brightest stars varies with the concentration class of the cluster, but is relatively constant for clusters of the same concentration class. It ranges from absolute magnitude –0.5 for the globular clusters poor in stars, to –1.3 for the rich clusters. This makes a second very useful criterion of distance.

(3) In the first searchings after distances of globular clusters, when magnitudes of individual stars in the clusters, either variables or bright stars, were unknown, Shapley[39] used the total magnitude and apparent linear diameter of the cluster. Assuming that these were the same for all globular clusters, a rough approximation to the distance could be worked out. Since we know now that there is a large dispersion in these quantities from cluster to cluster, this will have little application in the future.

How all these distance determinations of the clusters are affected by the presence of absorbing matter in the galaxy will be discussed in detail by Dr. Beals in the next paper. When the first determinations of the distances of globular clusters were made in 1918 the presence of absorbing matter was not universally recognized and as a result the dimensions of the galaxy were made much too large, with the distance from the sun to the centre placed at 13 kiloparsecs.

(D) *Present idea of the globular cluster system.*

With the publication of Trumpler's paper[41] on galactic clusters in 1930, it was realized that absorption in space could no longer be

neglected in a determination of stellar distances. Trumpler suggested the value of the absorption coefficient as 0.67 magnitudes per thousand parsecs. In a series of papers, van de Kamp[42] applied an absorption correction to the 1929 determination of globular cluster distances. Assuming an optical thickness of 0.8 magnitudes, he derived a distance to the centre of only 5.5 kiloparsecs. Several years later Stebbins and Whitford[10] from their painstaking work on colours of globular clusters discussed the amount of absorption to be applied, and determined a distance to the centre of 10,000 parsecs. For any of

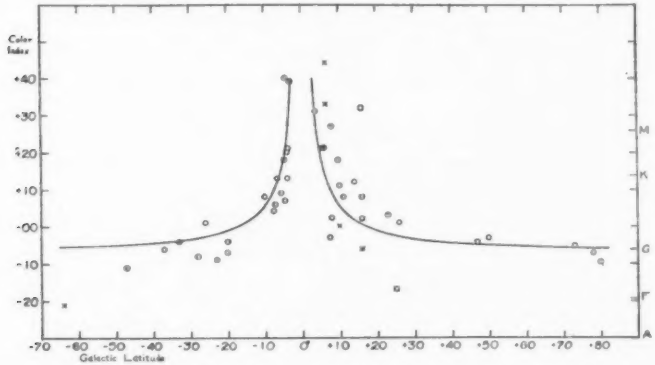

Fig. 3.—Colour indices of globular clusters, from Stebbins, P.N.A.S. vol. 19, p. 225, 1933.

the clusters in low latitudes, the amount of absorption correction to be applied is still somewhat uncertain, since the clouds of nebulous material are irregularly distributed along the Milky Way. The dependence of colour of globular clusters upon galactic latitudes is shown in figure 3, from a diagram by Stebbins.

If however, we consider the distances of globular clusters in high latitudes, then we can derive a set of distances with real meaning. I wish now to discuss a list of thirty clusters in high latitudes for which Shapley[43] last year published revised distances. The picture which I am now drawing of the galaxy is based on only one-third of the known globular clusters, but it is the third for which we feel reasonably sure that we know the distances.

These distances are based on photometric work of many obser-

vatories, including considerable work done at both the Dominion Astrophysical and the David Dunlap observatories. The cosecant law for the general absorption haze over the sky was taken into account in these computations. Long-exposure photographs show that these particular clusters are not mixed in with any discrete clouds of nebulous material.

The distances for these clusters from our solar system range up to 56,000 parsecs. (A parsec is equal to 19.2 millions of millions of miles). The most distant globular cluster is NGC 2419, at a distance of 56,000 parsecs, while the nearest cluster whose distance is well determined is 47 Tucanæ, 7,600 parsecs away.

As was pointed out many years ago, most of these clusters are concentrated in the direction of the centre of our galaxy, in the constellation of Sagittarius. Obviously most of the sixty clusters omitted from this paper will lie in this region of the sky because in this direction the absorption is greatest. In the general direction of the centre, but still in high latitudes, the most distant cluster is NGC 7006, at a distance from us of 44,000 parsecs. It should be pointed out that the discovery of additional globular clusters in high galactic latitudes is not probable. For high latitudes the list should be essentially complete.

The coordinates published in Shapley's paper for the thirty clusters were R, the distance from us, and $R \sin b$, the distance from the galactic plane, where b is the galactic latitude. As has been done with earlier distances, I have transformed these co-ordinates into

$$R \cos b \sin (l\text{-}327°), \text{ and } R \cos b \cos (l\text{-}327°)$$

in order to represent the distribution of these objects on the plane of the galaxy and at right angles to it. The symbol l represents galactic longitude, and the longitude of the galactic centre is taken as 327°.

Figure 4 represents the thirty globular clusters plotted on the plane of the galaxy, that is, the XY plane, in which

$$X = R \cos b \cos (l\text{-}327°) \text{ and } Y = R \cos b \sin (l\text{-}327°).$$

The sun and earth are at the origin of the co-ordinate system. The skew distribution of the globular clusters is at once apparent—in one quadrant there are no clusters. This is a real effect of distribution,

and not merely of neglecting the sixty clusters whose distances are of doubtful value. None of them would fall in this region. This skew effect shows that the sun is well toward the edge of the galactic system, that is, if we wish to see globular clusters we must look toward the centre of the galaxy.

If we compute the centre of gravity of this group of clusters, excluding NGC 2419, we find that it lies 7.3 kiloparsecs from us.

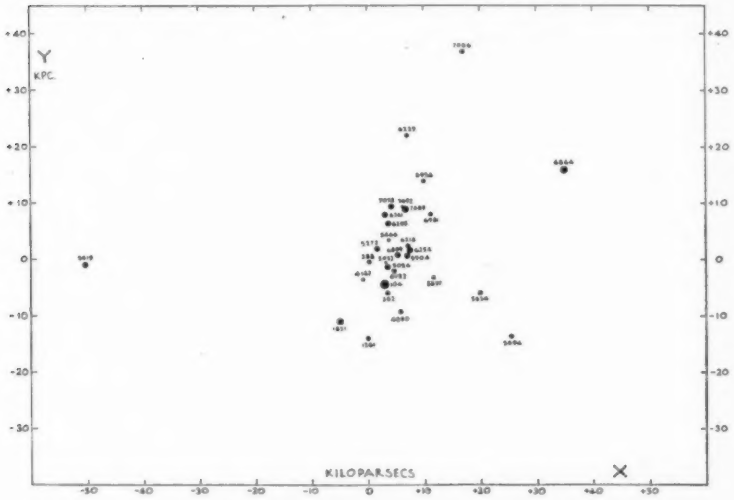

Fig. 4.—Thirty globular clusters plotted on the plane of the galaxy, the XY plane. Numbers refer to NGC designations of individual clusters; size of dot indicates absolute magnitude of cluster.

We can draw a circle 20,000 parsecs in diameter and centred about 7,500 parsecs from the sun that takes in practically all the globular clusters. Shapley says that the present distances confirm the distance to the centre of 10,000 parsecs. This diagram would strongly suggest a distance smaller than this—possibly not more than 8,000 parsecs.

A noteworthy feature is the number of clusters at very great distances above and below the galactic plane. This shows up best in figure 5, where the clusters are plotted in the *XZ* plane, perpendicular to the galaxy, where

X is $R \cos b \cos (l\text{-}327°)$ and Z is $R \sin b$.

The sizes of the dots are proportional to the total absolute luminosity of the clusters. It is surprising to see that the distances of clusters above and below the galactic plane are quite comparable to their distance along it. The clusters NGC 5053 and 5466, first investigated by Baade[44], and recently by me at the David Dunlap Observatory are at distances of 16,000 parsecs above the galactic plane. NGC 5466 is pictured in Plate *XIV*, which shows also the variable stars which are relatively abundant in these loose globular

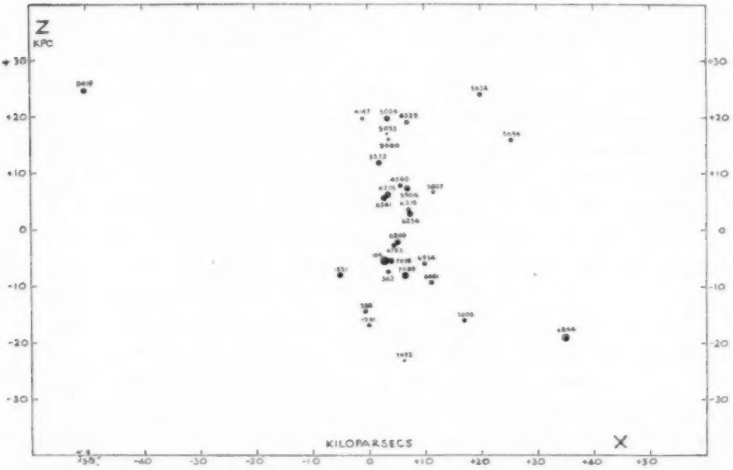

Fig. 5.—Thirty globular clusters plotted on a plane perpendicular to the galaxy, the XZ plane.

clusters. Light curves of typical cluster-type variables in this cluster, determined this year by the writer[45], are pictured in figure 6.

If our galaxy is a flat-shaped spiral, such as the great nebula in Andromeda, we would appear then to have a central nucleus of somewhat globular form, with a radius of ten or fifteen thousand parsecs.

The globular clusters are not the only objects in our galaxy to be found at large distances from the galactic plane. It has been pointed out frequently that cluster type Cepheids and high-velocity stars are found at great distances from the Milky Way plane. Re-

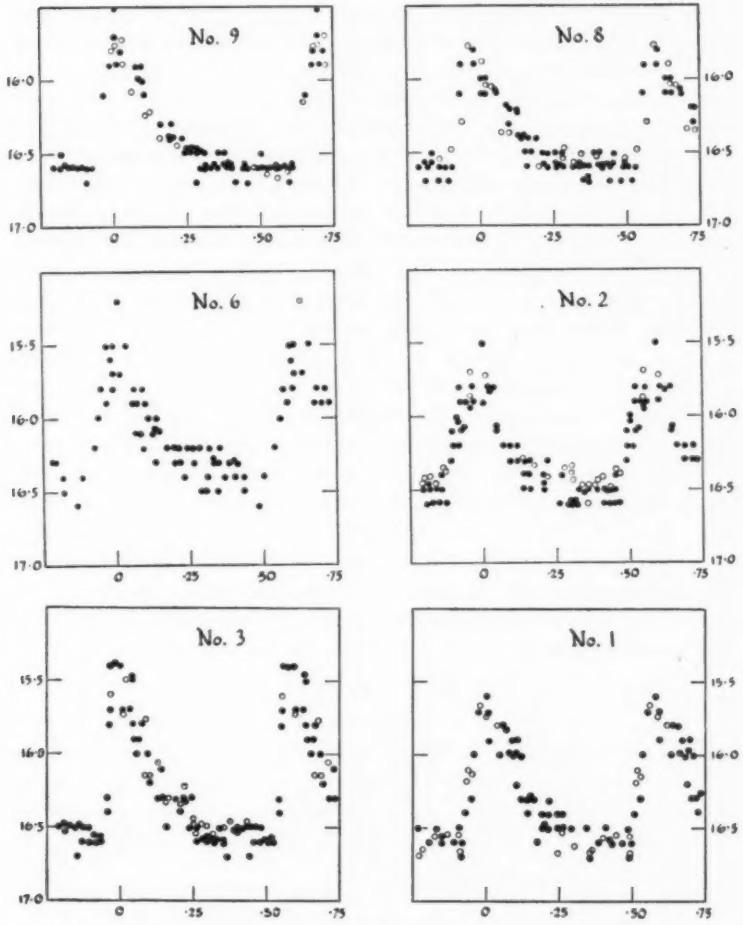

Fig. 6.—Light curves of six of the cluster type variables in the loose globular cluster, NGC 5466. From Sawyer, Pub. D.D.O., No. 17, 1945.

cent work at Harvard[46] shows the presence of these isolated cluster variables, not connected with clusters, at greater and greater distances in high latitudes.

From the system of globular clusters then, we derive a picture of our galaxy of some 40,000 parsecs in extent with material concentrated in a central region of probably half this diameter.

But what of the cluster NGC 2419 at a distance of some fifty thousand parsecs in a direction opposite to the centre? The inclusion of that one cluster would enormously increase our estimate of the size of our galaxy. It would increase it so much as to bring it completely out of line with any other galaxy we know in the sky.

This cluster has been conveniently dubbed "the inter-galactic tramp", and for the present it would appear best not to let it weigh too heavily in discussing the dimensions of our galaxy. We should not forget it; but neither in my opinion, are we justified in saying that because it is there our galaxy has an extent of 200,000 parsecs.

It is well to point out that the distance determination of this particular cluster is one of the most reliable that we have. The work was done by Baade[47] with the 100-inch Mount Wilson telescope. The cluster is one of the most difficult in the sky to investigate, but he did it with great precision and thoroughness. The cluster is certainly there, and at that great distance. But whether it actually belongs to our galaxy is not to be settled at the moment.

(E) *Globular clusters in the scheme of the universe.*

The cluster NGC 2419 brings into the discussion the problem of where globular clusters fall in the general scheme of the universe. They are enormous systems of stars—maybe of a million stars in an enormous volume of space. Are the globular clusters in the course of countless ages disintegrating into the star clouds which make up the Milky Way? Were the globular clusters formed at the same time as our galaxy was created, or have they evolved since? In 1929 Lundmark[48] asked the question, "Are the globular clusters and the anagalactic nebulæ related?" He suggested that our galaxy with the Magellanic Clouds and globular clusters formed a cluster of anagalactic objects.

The time is not yet ripe for answering all of these questions, but the evidence on galaxies and star clusters is accumulating at such a rapid rate that in a few years we should be able to make

intelligent guesses on some of them. In form and make-up the globular clusters resemble more the elliptical nebulae than they do either the galactic clusters or the galactic star clouds. The great range in absolute magnitude of globular clusters has already been noted. Shapley[15] has pointed out that the giant globular cluster in the southern hemisphere, 47 Tucanæ (NGC 104), is quite comparable in stellar content with the elliptical nebulæ, and, as seen from space, our galaxy and 47 Tucanæ might look like the Andromeda nebula with its elliptical companion NGC 205. And in 1938 at the Harvard Observatory was found a giant cluster of spherical form in Sculptor[49], resembling an enormous and faint globular cluster. This was quickly followed by the discovery of a similar object in Fornax.[50] Baade and Hubble[33] pointed out that these were extra-galactic systems lacking in supergiant stars, but close enough to be resolved.

It is only in this twentieth century that the spiral nebulæ have been resolved into stars. For years astronomers had felt that these great nebulæ were systems of stars beyond our own galaxy because the spectroscope showed a stellar spectrum. The final proof came when Hubble[51] on photographs of Messier 31 in Andromeda and Messier 33 in Triangulum detected individual Cepheid variable stars and novæ whose light changes he measured. From these measures he derived a distance of around 800,000 light years for those two nebulæ. A number of other spiral or irregular nebulæ have been resolved into stars since then with improved instrumental technique.

For the past twenty years, however, the central nucleus of the Andromeda nebula and the whole group of external galaxies known as the elliptical or globular nebulæ defied resolution into stars. The Andromeda nebula has two companions known to be at the same distance. These are elliptical nebulæ, much smaller than the spiral they accompany. Although the spectroscope showed a stellar spectrum, until two years ago no stars had been photographed in them.

The problem has been solved by Baade[26], who reasoned that if the brighter stars in these nebulæ were fainter and redder than the bright stars in the spiral arms, then they would be below the limits of the 100-inch telescope in the ordinary photographic blue light. But on special red plates, sensitive to wave-length 6300-6700 A.U., the red stars might be reached. Accordingly he took photographs on

red plates, with maximum possible exposure-times of three to four hours, on specially selected nights when the temperature was such that the figure of the mirror would not change during the exposure and the telescope focus would therefore stay constant for three or four hours.

The result was a triumphant resolution of the nucleus of the Andromeda nebula into stars, and of the resolution of its two elliptical companions. Whereas the brightest stars in the outer parts of spirals have absolute magnitudes up to –5 or so, the bright stars in the nucleus or in the elliptical nebulæ have absolute magnitudes of only –2. This accounts for the failure of the biggest telescopes to pick them up before this. Even on the red plates they are at the ultimate working limits of the 100-inch telescope. The new 200-inch, however, should enormously increase our knowledge in this direction.

For years the elliptical nebulæ have been known to be much smaller in size and content than the great spirals. The discovery of the Sculptor and Fornax clusters at Harvard, and the resolution into stars of the elliptical nebulæ NGC 147 and NGC 185, the centre of the Andromeda nebula, and its two companions by Baade, now brings into prominence this whole sequence of stellar forms. There is now established within the sequence of galaxies, a class of elliptical or globular nebulæ which are distinguished from the spirals by (1) their smaller size, (2) their smaller content of stars, and (3) the fact that their stellar population is of a different type, lacking in bluish stars of great total luminosity.

Within the sequence of elliptical or globular galaxies there is a considerable spread of absolute magnitude and stellar content, just as within the sequence of globular clusters there is a wide spread in these two quantities. A further resemblance here is that cluster type Cepheids have already been noted in some of these systems, notably the Sculptor cluster, just as they have in most globular clusters.

Up until the past few years we have thought of globular star clusters as a class of objects having no resemblance to anything else in space. Now, however, astronomers are beginning to find some resemblance to them in other objects. Baade thinks that the gap between an elliptical galaxy and a globular cluster is too great ever to be filled by the finding of intermediate forms. The linear diameter of

an elliptical galaxy is of the order of one thousand parsecs; while of the biggest globular clusters it is only one hundred parsecs. He considers that the density of stellar population in a globular cluster is 40-100 times greater than in an elliptical nebula. You have just heard the admirable address by Dr. J. K. Robertson, President of the Royal Society, on the subject of continuity and discontinuity in nature. Here is an example of the problem. Is there a discontinuity between the objects we call globular clusters and the elliptical nebulæ, or may they eventually be found to form a continuous sequence?

It is probable that smaller elliptical nebulæ will be found. New members of our local group of galaxies are still being discovered, as witness these two new ones found last year by Baade[34]. We still may not know all the galaxies which lie within only one million light years of distance from our own. It is obvious that those still to be found will be smaller and smaller, not larger and larger.

Summary. We picture our galaxy as a vast system extending for 30 to 40 thousand parsecs in its long direction, and dotted about on all sides with more than a hundred giant star systems subsidiary to it at distances as great as 20 thousand parsecs from the plane. If we look off into space we can see other galaxies dotted around with globular clusters. We see spiral galaxies like our own. And we see a different sequence of galaxies which resemble globular clusters, with stars scattered around in a symmetrical spherical form with absence of bright nebulosity and of very bright stars. We wonder if eventually elliptical nebulæ with smaller diameters will be discovered to form a connecting link with the giant globular clusters.

REFERENCES

[1]Perrine, L.O.B. No. 155, 1909.
[2]Hinks, M.N. vol. 71, p. 693, 1911.
[3]Hertzsprung, A. N. vol. 192, p. 261, 1912.
[4]Bailey, H. A. vol. 38, 1902; H. A. vol. 76, No. 4, 1915.
[5]Shapley, Mt. W. Cont. No. 152, 1918.
[6]Hubble, Mt. W. Cont. No. 485, 1934.
[7]Shapley, Star Clusters, p. 224, 1930.
[8]Shapley, H.C.O. Bull. No. 902, p. 26, 1936.
[9]Shapley and Paraskevopoulos, H.C.O. Bull. No. 914, p. 6, 1940.
[10]Stebbins and Whitford, Mt. W. Cont. No. 547, 1936.
[11]Shapley and Davis, P.A.S.P. vol. 29, p. 177, 1917.
[12]Dreyer, M.R.A.S. vol. 49, Pt. 1, pp. 1-237, 1888.

[13]Shapley and Sawyer, H.C.O. Bull. No. 849, 1927.
[14]Christie, Mt. W. Cont. No. 620, 1940.
[15]Shapley, P.N.A.S. vol. 27, 440, 1941.
[16]Slipher, V.M., P.A.S.P. vol. 28, 191, 1916; Pop. Ast. vol. 25, p. 36, 1917; Pop. Ast. vol. 26, p. 8, 1918; Pop. Ast. vol. 30, p. 9, 1922; Pop. Ast. vol. 32, p. 622, 1924.
[17]Edmonson, A. J. vol. 45, 1-13, 1935.
[18]Humason, P.A.S.P. vol. 46, p. 357, 1934.
[19]Adams and Pease, P.A.S.P. vol. 25, p. 260, 1913.
[20]Pease, P.A.S.P. vol. 26, p. 204, 1914
[21]Fath, Mt. W. Cont. No. 49, 1911; Mt. W. Cont. No. 67, 1913.
[22]Cannon, H.C.O. Bull. No. 868, 1929.
[23]Stebbins, P.N.A.S. vol. 19, p. 222, 1933.
[24]Schwarzschild, H.C.O. Circ. No. 437, 1940.
[25]Cuffey, Ap. J. vol. 98, p. 49, 1943.
[26]Baade, Ap. J. vol. 100, p. 137, 1944.
[27]Sawyer, Pub. D.D.O. vol. 1, No. 4, 1939.
[28]Mohr, H.C.O. Bull. No. 895, 1934.
[29]Mohr, H.C.O. Bull. No. 899, 1935.
[30]Hubble, Mt. W. Cont. No. 304, 1925.
[31]Hubble, Mt. W. Cont. No. 452, 1932.
[32]Hubble, The Realm of the Nebulae, p. 144, 1936.
[33]Baade and Hubble, P.A.S.P. vol. 51, p. 40, 1939.
[34]Baade, Ap. J. vol. 100, p. 147, 1944.
[35]Shapley, Mt. W. Cont. No. 151, 1918.
[36]Leavitt, H.C.O. Circ. No. 173, 1912.
[37]Hertzsprung, A.N. vol. 196, p. 201, 1913.
[38]Wilson, R. E., Pub. A.A.S. vol. 9, p. 239, 1938.
[39]Shapley, Mt. W. Cont. No. 152, 1918.
[40]Shapley and Sawyer, H.C.O. Bull. No. 869, 1929.
[41]Trumpler, L.O.B. No. 14, p. 154, 1930.
[42]van de Kamp, A.J. vol. 40, p. 145, 1930; A.J. vol. 41, p. 81, p. 84, 1931; A.J. vol. 42, p. 1932; A.J. vol. 42, p. 161, 1933.
[43]Shapley, P.N.A.S. vol. 30, p. 61, 1944.
[44]Baade, Ham. Mitt. vol. 6, No. 29, 1928; Ham. Mitt. vol. 6, No. 27, 1926.
[45]Sawyer, Pub. D.D.O. vol. 1, No. 17, 1945.
[46]Shapley, M.N. vol. 94, p. 791, 1934.
[47]Baade, Mt. W. Cont. No. 529, 1935.
[48]Lundmark, Pop. Ast. vol. 38, p. 26; P.A.S.P. vol. 42, p. 23; Lund. Med. No. 119, 1930.
[49]Shapley, H.C.O. Bull. No. 908, 1938.
[50]Shapley, Nature, vol. 142, p. 715, 1938.
[51]Hubble, Obs. vol. 48, p. 139, 1925.

David Dunlap Observatory
Richmond Hill, Ontario.

SOME ADVANTAGES OF LONG FOCUS NEWTONIANS

By E. K. White

THIS paper deals briefly with some advantages found by the writer in the construction and use of Newtonian reflectors with focal lengths about twelve times the aperture, over the more commonly known f-8 mirrors.

In most articles dealing with the making of Newtonian reflectors the amateur is advised to choose a focal length about eight times the aperture of his mirror. Rev. W. F. A. Ellison says, "I recommend f-8 because it combines the easiest figuring with capabilities for excellent performance" (see page 385 in *Amateur Telescope Making*). Just what accuracy of figure is necessary in an f-8 mirror of (say) eight inches aperture to give excellent performance? It is an accepted fact that a mirror will give perfect definition if its surface be figured to one quarter wave-length of sodium light, or about five-millionths of one inch. It has been shown by Mr. F. B. Wright (page 257 in *A.T.M.*) that an eight-inch-diameter mirror of f-8 must have its surface within 33 per cent of a perfect parabola to give excellent results.

In the case of an eight-inch-diameter mirror of f-12, Mr. Wright tells us that it can be finished spherical and still give fine definition, for a sphere and a parabolic surface of this dimension are very nearly coincidental. The allowable tolerance from a perfect parabola for an f-12 eight-inch mirror is 110 per cent. Most opticians agree that it is less difficult to figure a spheroid than a parabola, and the former is most certainly easier to test by the well known Ronchi method (page 264 in *A.T.M.*). Also there are no r^2/R zones to measure as with the paraboloid.

The parabolizing of a mirror is necessary to correct the surface for the one aberration found in specula, namely spherical aberration. In other words a spherical mirror of around f-8 dimensions will not reflect the marginal and central rays of light from a star to the same focal plane. However, in small mirrors up to about ten inches aperture and of f-12, this is not the case. The old masters such as Herschel, With, and Lassell, who made their mirrors before Foucault's knife-edge test was known, realized that longer focal lengths enabled them to make better corrections on their mirrors, which also

meant better performance. Thus we find that most of their mirrors were made to f-10 and higher, and many of these specula did give very excellent performance.

Let us discuss further advantages of long-focus mirrors. It has already been shown that they are at least a little easier to finish, and I have found that an f-12 mirror "a little off," will give better images than an f-8 of the same aperture which is about equally imperfect in figure. Turned edge cannot be tolerated in either mirror, but slight zonal errors are not at all serious in the longer focal length.

Perhaps the most important advantage of long focus is that one can employ a smaller secondary mirror and therby reduce light loss a little, and diffraction effects a great deal. In my opinion few amateurs realize the bad effects on stellar images a secondary mirror has when its minor axis much exceeds one-sixth the diameter of the primary. One has only to place a cardboard disc about one-quarter to one-third the diameter of the main mirror on the secondary support directly in front of the flat or prism to see the bad effects it will have. For finest definition an elliptical secondary mirror that is really flat is superior to anything else.

The more common types of eyepieces are designed to work best with a slender cone of reflected or refracted rays, and the f-12 mirror will give flatter and better fields with Huyghenian and Ramsden oculars than will f-8 mirrors, which should really employ expensive achromatic eyepieces for best results. Also the f-12 mirror will enable one to obtain high magnification, should it be desired now and then, without seeking extremely short-focus oculars at high cost.

Two further advantages of lesser importance are: first, changes of air temperature actually have little effect on the image quality as a result of temporary changes in the long-focus mirror's shape while in use, but such is hardly true with f-8 mirrors of plate glass. Secondly, many amateurs take photographs of the moon using their reflectors as the camera. With focal lengths a little over one hundred inches the image of the moon at the focal plane of the primary mirror is about one inch in diameter. This is large enough to record quite an abundance of detail on a plate or film, and bright enough for rapid exposures. With such a sizable image the use of an eyepiece may be dispensed with altogether. The writer has taken some fair lunar photographs with an $8\frac{3}{4}$ inch, f-12 mirror on Panatomic film

using exposures as short as one-hundredth second. These negatives can be enlarged to at least eight inches, and the resulting prints are quite sharp.

It can be shown that the disadvantages of the long-focus Newtonian are few and not at all serious. Probably the outstanding one is that a longer tube will be necessary which will require a well designed and rigidly built mounting, costing little more however than a good one for an f-8 mirror. Provided the instrument is permanently mounted out of doors, its shelter will also require to be a little larger. The eyepiece position will be somewhat higher, but a good stepladder will bring it wihin easy reach. These disadvantages will be found to be of little consequence where the mirror is not greater than eight or ten inches in diameter.

While mentioning the longer tube, one may wonder if tube currents are increased, particularly when a solid metal tube is used. The writer has not found this to be the case with a nine-inch f-11 mirror mounted in a closed metal tube. ("Air Currents Within the Reflector Tube." This JOURNAL, November 1943).

The field of view will be smaller when using an f-12 mirror, yet with some Ramsden oculars of about one inch equivalent focal length, all of the moon's image can be seen in the field at one time with a mirror of about one hundred inches focus.

In conclusion it might be of interest to mention the performance one may expect when using a good, long-focus mirror as compared to that of an f-8 mirror on different classes of celestial objects. With double stars there will be a marked improvement in the images of an f-12 mirror, and there will be less diffraction effects with bright stars. The images will be crisp even with high magnification (in good seeing), and quite comparable to those seen with a refractor. Nebulae and clusters will appear in the f-12 mirror much as through a refractor of equal size; a shorter focal length mirror would of course give brighter images of these objects, provided apertures were the same.

With planetary and lunar detail the f-12 mirror comes into its own, and it is my opinion that such a good mirror will outperform any f-8 of the same aperture in this field. I have given an account of my observations of Saturn using a nine-inch f-11 mirror elsewhere. ("Saturn with a Nine-inch Reflector," *Sky & Telescope*, March 1945.)

The writer hopes that amateurs who are contemplating the construction of a mirror will give the long focus some thought before deciding upon the usual f-8 focal ratio, and the tyro who may dread the difficult task of parabolizing cannot go far wrong in trying out a six-inch spherical mirror of about seventy-five inches focal length.

Chapman Camp, B.C.,
Canada.

HER MAJESTY'S MAGNETICAL AND METEOROLOGICAL OBSERVATORY, TORONTO

By A. D. THIESSEN

(Continued from page 278, this volume)

Toronto, 23rd June, 1847.

Sir,

I have the honor to report to you that on the arrival of the Ordnance Estmates for this station, for the current year, it appeared that the expenses of the Magnetic Observatory were not included, and in consequence, that the Ordnance Storekeeper is without authority for any expenditure on that account. The previous authority expired on the 31st March, although he holds a balance to the amount of £189. 10. 9. in his hands, principally out of the district contingent allowance of £50 for expenses connected with the Magnetic Survey. In begging that you will draw the attention of the Honorable Board to this omission, I beg leave to suggest that it would tend to prevent any recurrence of it, if the storekeeper were directed to include all the authorized expenses of the Establishment in his own local estimates until otherwise ordered.

I have, etc.,
J. H. L.

Lieut. Col. Sabine,
Superintendent,
Magnetic Observatories, etc.

Magnetic Observatory,
Toronto, July 9th, 1847.

Sir,

With reference to the subject of my letter of the 19th June ultimo, I have the honor to state, that it appears that the authority which I requested from His Excellency the Commander of the Forces, to the Commissariat Department, to continue the issue of all allowances whether of rations or extra pay, on account of the Magnetic Observatory for which the special authority expired on the 31st March ultimo, was insufficient for the purpose intended, and that an authority is required to enable the D. O. Storekeeper to draw upon the Commissariat for such expenses. I have now the honor to request that the Ordnance Department may be authorized to continue the payment of accounts presented for the contingent expenses of the Magnetic Observatory and of the extra pay of the Detachment to an amount not exceeding in the aggregate the sum of £189. 10. 9. Sterling, being the unexpended balance in the hands of the Storekeeper, on two

grants of the Honorable Board for the expenses of the Observatory up to 31st March, ultimo, dated 5th August, 1846, S-2069, and Nov. 1846, T-605.

I have, etc.,
J. H. L.

The Military Secretary,
etc.

Magnetic Observatory,
Toronto, 1st May, 1848.

Sir,

I have the honor to report to you that the ordnance storekeeper at this station is apprehensive of being shortly without authority for continuing the necessary payments on account of the Magnetic Observatory, in consequence of the specification of the amount requisite for one year's expenditure, only, the letter from the Honorable Board of Ordnance, under which he is at present acting (27 Sept. 1847, 3/473). Although that letter, taken in connexion with a previous one addressed to yourself (28 July 1847, ?/2218) is considered to have reference to the continuance of the Establishment for the two years then authorized by H. M. Treasury.

I have therefore to request that you will be pleased to make application for the necessary authority to him for carrying on the Service to the end of the time authorized.

I also beg to take this opportunity of requesting that the present authority may be made to cover the whole financial year to 31st March 1849, instead of terminating with 1848, as it is not customary to relieve Detachments in Canada during the winter, and as it is probable that after conclusion of the regular observations on the 13st December of the present year, there will be supplementary work which will fully employ the officer and the N.C. Officers, until the spring. I presume it will be the intention of the Master General that the extra pay of the Detachment will be continued upon the spot until it is relieved, which in the regular course of things may be soon after the period I have named.

I have, etc.,
J. H. L.

Lieut. Col. Sabine, R.A.,
Supt. Mag. Observatories,
etc., etc., etc., Woolwich.

Magnetic Observatory,
Toronto, 17th November, 1849.

Sir,

I have the honor to request your attention to the circumstance that no Instructions have hitherto been received by the Dep. Ordnance Storekeeper at this Station having reference to the continuance of this Establishment, and that in consequence no contingent accounts have been payable, nor has the Extra Pay at the Detachment been issued since the 31st March ultimo. In bringing this subject to the Notice of the Honorable Board of Ordnance may I request

that you will take steps to provide against a recurrence of the circumstance on the expiration of the Current Year?

I have, etc.,
J. H. L.

Lieut. Col. Sabine,
Superintendent,
Magnetic Observatories.

Magnetic Observatory,
Toronto, 3rd May, 1850.

Sir,

I have the honor to request your attention to the circumstance that the Ordnance Storekeeper at this Station has not received the necessary authority for defraying the expenses of the Magnetic Observatory during the current year, commencing from 1st April ultimo.

I have, etc.,
J. H. L.

Lieut. Col. Sabine,
Royal Artillery,
Superintendent of Magnetic Observatories.

Toronto, June 5, 1850.

My dear Colonel,

The last settlement of accounts between us, to my knowledge, was in October 1848 when you paid into Cox's £25 15 9 for the extra pay of Serjeant Johnston at 9d a day from 1 Dec. 1846 to 31 July 1848 and also a gratuity to Serjeant Walker. I subsequently paid Serjeant Johnston £13 13 9 for which receipts have been duly transmitted. Since his retirement I have employed him for specific purposes and paid him by the task, in all £7 10. I sent a receipt for a portion of this sum on the 24 May. I send one for the balance now, together with a receipt for a second gratuity of £4 to Serjeant Walker, who has performed the same duties as were before performed by Johnston, with equal diligence and fidelity, and to whom an occasional gratuity is a still greater object. The senior N.C. Officer, whoever he may be, has to devote much of his own time to the preparation of returns and other business, and does certainly deserve a better remuneration than the others. I hope therefore you will approve of my having given him this encouragement.

We have then as due to me, unless you have paid anything to Cox since October 1848:

Advance of pay to Serjt Johnston	£13	13	9
Pensioner Johnston for sundry calculations	7	10	0
Gratuity Serjt Walker	4	0	0
	£25	3	9
Due me by the Admiralty for Fox's dip circle	£25	0	0
	£50	3	9

We have I think always valued the Fox at the above amount. It cost me either £25 or £30 and I paid £6 for putting it into perfect order when you first sent it to the Cape.

You paid £4 to Mr Wild for my second years' subscription to the RS but this he was to refund on cashing my subsequent order. You also paid 16s postage for a thermometer, which I remitted lately to Younghusband. I am not aware of any other payments.

Believe me
Very truly, yours
J. H. Lefroy.

Lefroy was very happy "to have occasional opportunities from 1842 to 1877 of renewing intercourse with American scientific men" and found his visits to American scientific society meetings "a very delightful approach to the most intellectual American society."

This friendly collaboration with the leading scientists in the United States redounded greatly to Canada's benefit, as the following letter will make abundantly clear:

From Prof. Loomis.

New York University,
June 25, 1850.

Dear Sir,

I have received your letter of the 11th ultimo in which you speak of the possibility, or perhaps probability of the discontinuance of the Toronto Observatory. I am not yet in a condition to give an opinion how far the Toronto Observatory may have definitely settled the questions in magnetism, for the solution of which it was founded, as I have only seen the first volume of the printed observations for 1840-41-and 42. I am not aware indeed, whether any other volume has been published. But I should be tempted to consider the meteorological observations as a sufficient grounds for maintaining your Observatory for a longer period.

The plan which I proposed several years since of organizing a grand system of magnetic observations to comprehend the entire continent, has not been abandoned. The scheme has been adopted by the Smithsonian Institution, and they are adopting measures for carrying it into execution. These measures proceed slowly, nevertheless a good deal has already been done. I suppose Prof. Henry is not yet in a condition to call upon the British Government for co-operation. Yet I think he will be ready soon, and we have had assurances from Col. Sabine that when the call was made it would be responded to. In that case it seems to me that it would be very important to have a model observatory somewhere in British America, to which the British observations should be regularly reported, and that Toronto is the proper place for such an establishment.

For this reason I feel very anxious to have the Toronto Observatory still maintained, and I wish I was able to speak more understandingly of the magnetic

observations. With respect to any influence which could be exerted upon the British Government I have thought the following to be the wisest course to pursue. There will be a meeting of the American Association for the Advancement of Science at Newhaven in August, and I propose to bring this subject before that body. I will endeavor to obtain an expression of opinion on the whole matter, and if anything coming from America could have influence in London, I suppose it would be such an expression of opinion. In the mean time if any other of the Toronto observations have been published which would enable us better to judge how much you have accomplished, it might be worthwhile to forward them for our examination. I will endeavor to see that the subject is fairly presented to the members of the Association.

With much respect I remain, etc.,

E. Loomis.

Magnetic Observatory,
October 25th, 1850.

Sir,

I have the honor to report to you that no action appears to have been taken on the subject of my letters of 3rd May and 14th July ultimo. The Ordnance authorities on the station have received no instructions relative to the issue of the working pay of this detachment or the Contingent allowance for the observatory both of which are in arrears from 31st March ultimo.

The great inconvenience experienced from this state of things and the repeated applications made to me by tradesmen for the amount of their various accounts, induces me to request that the matter may again be brought before the notice of the Honorable Board, and if possible an order be obtained for continuing all regular and authorized pecuniary issues, even when the customary authority is from any cause delayed. The officer in charge of the Observatory being at all times in possession of sufficient information as to the actual continuance of the Observatory to make him fully responsible that the allowances are not drawn after the period for its abandonment or transfer shall have arrived.

I have, etc.,

J. H. L.

As we have seen, the annually recurring worry for the Director was the question whether the establishment would be continued, and the difficulty of obtaining funds and supplies during the interim between the end of the fiscal year and the granting of contingent funds for the new year.

Minor worries were such things as the setting up of a Board of Survey on Greatcoats for the army officers every winter,[86] on one occasion obtaining trousers for his men so that they might "appear properly on Sunday . . . fit for parade" and to be "marched to church,"[87] to supply his men with textbooks on artillery,[88] or to

complain about the condition of the Barrack bedding newly issued and found to be "excessively dirty, and with so offensive a smell as to make me suppose that they have been issued by mistake."[89]

Rations, especially for the women and children, also were a continued cause of inconvenience.

Magnetical Observatory,
Toronto, 4th August, 1848.

Sir,

In returning the Ration List of this Detachment, as amended to your directions, in conformity to the Regimental Order dated Head Quarters 5th July, 1848, I have the honor to request that you will be pleased to forward to the officer commanding the Royal Artillery, for reference to the Commander of the Forces, an application for a renewal of the authorities by which this Detachment has hitherto been placed, in this respect, upon a footing distinct from that of Detachments receiving rations under Regimental Orders.

I apprehend this course to be that which is pointed out, by the specification of the order in question, that the return embraces "Free rations to be drawn for the wives and children of the N.C. officers and soldiers in the command *exclusive of any* which may be granted temporarily by General Order."

The Detachment serving at the Magnetical Observatory was originally supplemental to the Force Serving in Canada, none of the men belonged to companies on the station, and the rations issued to their wives and families formed no portion of the total number allowed by regulation to the Royal Artillery on the Station. It was thought fit, in consideration of the nature of this service, to afford every encouragement to the N.C. Officers and men employed, and rations were granted to the families of all those (two in number) who were married. On my joining the Detachment in October 1842, with a married Gunner as servant, the same privilege was upon my application, granted to his family. The Detachment has continued to draw the same rations since that time, and I beg leave to represent that the reasons which occasioned the privilege to be granted in the first instance, remain unaltered.

I have the honor to enclose copies of the correspondence and orders forming the authority upon which this detachment has hitherto received rations for three women and their children, and to request that in addition to the rations for one family allowed by the Regimental Order of 5th July, the Officer Commanding the Royal Artillery will be pleased to make application for authority to draw two more rations to complete the number hitherto received.

I have, etc., J. H. L.

Lieut. Col. Dalton,
Kingston.

EXTRACT Toronto, U.C., 18th Nov., 1839.

Sir,

. . .

I have also ascertained from the perusal of these letters that the usual directions have been given to the Commissiariat Department to issue rations to the

Non Commissioned Officers and men to be employed under my orders in making magnetic observations, but omitting to mention the officer and the wives and families of the two Gunners who were permitted to come out from England with the Detachment and in consequence of which a doubt was expressed by the [District Company General] as to his being authorized to issue rations to me without a specific authority.

I therefore beg leave to request that His Excellency would be pleased to authorize the issue of rations to the Officer, Non Commissioned Officers and men, and to the wives and families of two of the men of the Detachment to be employed in making magnetic observations from the dates of their respective arrivals at Montreal and Quebec.

I have . . .
C. J. B. Riddell, Lieut.,
Royal Artillery.

The Military Secretary,
Montreal.

Head Quarters, Montreal,
25 Nov., 1839.

Sir,

I am further to observe that with regard to your being allowed rations there does not appear a doubt as you are in command of the Detachment, and that His Excellency has been pleased to sanction the issue of the usual portions to the families of the Non Commissioned Officers and men of the Party.

I have . . .
C. R. O'Donnell,
Lieut. Col. M.S.

Lieut. Riddell, R.A.,
Toronto

Montreal, 26 Dec., 1842.

General Orders.

No. 2. The Commander of the Forces has authorized the issue of rations to one Woman and two children, the family of Gunner and Driver George Cooper, Royal Artillery, attached as a Servant to the officer commanding the magnetic Establishment at Toronto.

I. Eden, D.A.G.

ABSTRACT OF ISSUES

Five Free (whole) Rations of Provisions have been overdrawn by this Corps. It has been discovered in this office that this overissue occurred at Toronto. One Child of 7 years having died at the Magnetic Observatory on the 11th January 1850, but nevertheless returned for Rations to the end of that month.

Commissariat, Quebec,
25th March, 1850.

By order
W. H. Ussher
D. A. Cy

True copy of a copy,
F. W. Hastings, Lieut. R. Arty.

R. A. H. Qr. Office.
Montreal, March 28th, 1850.

Sir,

I am directed to annex a copy of an extract from observations on the accounts of the Depy. Comy. Genl. at this station for the month of January last, and to request that you will call on Captain Lefroy commanding at the Magnetic Observatory, Toronto, to credit the number of free rations overdrawn in that month by the detachment under his command and forward a report to this office when the above instructions have been complied with.

I have the honor . . .
F. W. Hastings, R.A.,
Acting Adjutant.

Lieut. Col. Dalton, Comdy. Roy. Arty.
Kingston, C.W.

MEMO. Sent for Capt. Lefroy's information who will be pleased to report to this office, when the order has been complied with, and return this letter.

Chas. Dalton,
Lt. Col. R A.

District Office,
R.A. Kingston, 1st April, 1850.

Magnetic Observatory,
Toronto, 7th April, 1850.

Sir,

With reference to the remark made at the Commissariat Office at Quebec upon the Rations issued to the Detachment under my command for the month of January, 1850, I have the honor to state that the five rations supposed to have been overdrawn were duly accounted for in the next following returns by reference to which it will be seen that the return for the month of February includes only 303 lbs. instead of 308 lbs., the full quantity. The ration returns of this detachment, being by special permission, made out monthly, an alteration such as that which has led to this correspondence, can not be corrected, until the following month.

I have the honor to be . . .
J. H. Lefroy . . .

Lieut. Col. Dalton,
Commanding Royal Artillery,
Kingston, C.W.

Among the vicissitudes of the early directors of the Observatory was the fire hazard. On May 16, 1850, Lefroy wrote to Colonel Sabine that the "Transit Instrument had a narrow escape the other day. I had sent it to an instrument maker for a new set of spider lines. Within twelve hours after its return, his house and a dozen or two others, were burnt to the ground. We had a great fire, one might say, our annual great fire."

On June 14th of the same year a lamp used to make photographic records caused a serious fire in the Observatory, which "very nearly resulted in the destruction of this building."

Toronto,
June 14, 1850.

My dear Younghusband,

I have but a few minutes in which to report a serious accident, very nearly resulting in the destruction of this building. The barometer lamp of Mr. Brooke's instrument set fire to the massive wooden stand supporting the Cylinder, last night, between 8h and 10h and completely ruined the whole of that portion of the apparatus. The Timepiece injured by heat, and by its fall when the stand gave way. Temper of all the springs altered; balance wheel broken; cannot be repaired here, but if sent home free of expense may perhaps be repaired with less cost than a new instrument. *Fixed lenses.* The larger of the two (magnetic lens) ruined, the smaller will do again.

Barometer—broken to pieces. The wheel will do again.

I have still the old time piece, and shall try to make it do, using the barometer lens for the magnet. It will allow a range of 1° 20′. As a substitute for a glass cylinder, I shall make use of an electroplated copper one. The reflector magnet lamp and stand escaped uninjured, it will therefore be practicable to restore the register of the Declination I trust, but I shall be glad to receive the new instrument. I attribute the accident to the barometer lamp being dirty, and the ignition of the whole body of camphine. I have been working with miserably bad stuff lately. There is none manufactured nearer Toronto than New York. Walker who was on duty behaved very well. We probably owe the safety of the building to his promptitude. The smoke was so suffocating that he could only enter the room on the hands and knees, but he got a few buckets of water, and pitched it in at haphazard. I attribute to this the destruction of the larger lens, which is broken in two and curled like the letter S. I have not time to write to Mr. Brooke; will you inform him? If he is really going to send out the other instrument, it may not be necessary to replace this one, but if that is uncertain, since I consider it very important to have an automatic register of Declination changes, I hope he will send out a new time piece, a fixed lens and a Barometer with lamp complete. If we remain here, I will manufacture my own camphine, and have a good article. Detestable as it is, I would rather continue to use it than give the thing up.

I have had a very favorable letter from Prof. Henry about the desired co-operation of the American Academy in our matter. He will do all we want. I wrote also to Loomis, Bache, and Bond.

I much regret that time has not permitted adding fuller notes of the Auroras to my disturbance papers. I rely however upon those notes being printed with the observations somehow.

Yours in haste,
J. H. Lefroy.

(*To be continued*)

REVIEW OF PUBLICATIONS

Optical Instruments by Earle B. Brown. 5½ × 8½ in., 567 + xii pages, 1945. Chemical Publishing Co. Inc., Brooklyn, N.Y. Price $10.00.

The book appearing under the above title might appropriately be called a primer of optical instruments and their use. The fundamentals of a great many instruments are set forth briefly but clearly. The author brings to the subject the experience of the application of optical instruments to military uses and embodies in the book many hints on the effective use and care of such equipment.

About one-third of the book is concerned with elementary geometrical optics, which the reader could find in any good treatise on the subject, but it does not detract from the book to have the necessary formulae and principles so very conveniently summarized. The book is rather expensive but is printed on fine paper and copiously illustrated with large diagrams.

R. K. Y.

The Arc Spectrum of Iron (FeI), by Henry Norris Russell, Charlotte E. Moore and Dorothy W. Weeks. 9 × 12 in., 100 pages. Transactions of the American Philosophical Society, New Series, vol. xxxiv, part II, 1944. Philadelphia 6. Price $2.25.

This book is made up of two parts, the analysis of the arc spectrum, by Professor Russell and Miss Moore, and the Zeeman Effect, by Miss Weeks. The bulk of the publication is made up of extensive tables of term values, line identifications and Zeeman patterns of neutral iron atom. Due to the astrophysical, physical and metallurgical importance of this element, and to the accuracy and completeness of this work, these tables may be regarded as spectroscopically indispensable and classical.

Russell and Moore's lists contain 4860 classified iron lines. Of these only 3606 have been as yet observed in the laboratory; the remaining 1254 are predicted iron lines which have been identified in the spectrum of the sun. The 4860 lines represent 1342 multiplets; these arise from combinations among 464 energy levels belonging to 146 terms. The term analysis is made much more com-

plete and definite, due to information derived by Miss Weeks from M.I.T. Zeeman plates.

A detailed discussion of the material includes a new determination of the ionization potential of iron, 7.858 volts, correct to within a hundredth of a volt. A study of the probability of accidental wave-length coincidences in the identification of predicted iron lines in the solar spectrum leads to the conclusion that amongst the good and fair identifications these coincidences have little effect; that the identifications are physically significant.

The authors regret that the laboratory observations of this classical complex atomic spectrum is still so incomplete. They suggest that as all laboratory sources are still very poor compared with the solar spectrum, new approaches be sought for the production of rich iron spectra in the laboratory. "A great deal of work will still be required before this 'familiar' spectrum is really thoroughly known, and it still offers attractive and remunerative problems for the observer." Recalling Russell's uncanny ability to predict fruitful research fields in the past years, physicists and astrophysicists should ponder well this suggestion.

F. S. H.

NOTES AND QUERIES

Communications are invited, especially from amateurs. The Editor will try to secure answers to queries.

Prisoner of War Liberated

Lieut. George H. Tidy, RCNVR, a Japanese prisoner-of-war since March 1942, has been liberated and reported safe in Calcutta. Lieutenant Tidy was on the staff of the David Dunlap Observatory for two years prior to enlisting in the Canadian Navy in the summer of 1940. In the Navy he specialized in radar work, and was on loan to the Royal Navy, serving aboard the H.M.S. *Exeter*. As mentioned in this Journal (April 1942, March 1943) Lieut. Tidy was reported missing after the loss of this cruiser in the Battle of the Java Sea, and not until a year later was he reported a prisoner in Java. Another year and a half elapsed before his mother received a post card, the first direct message from him. His friends in the Astronomical Society welcome the news of his liberation, and entertain the hope of a speedy return.

F. S. H.

Eclipse of the Sun of July 9, 1945, at Montreal

The following report of observations of the Eclipse of July 9, 1945, was received too late for inclusion in the last issue.

Partial Solar Eclipse of 9th July 1945 as viewed from Ville Marie Observatory, Montreal, Que., by DeLisle Garneau, Director of Observations of the Montreal Centre, assisted by Francis P. Morgan and J. Edgar Guimont, members of the Council.

(1) Equipment: Society's 6-inch refractor, with 45 power eyepiece, with image of sun projected on white surface.

Stop-watch, set by radio time-signals of the U.S. Bureau of Standards.

Time of Contacts recorded

2nd contact: 8 h. 14m. 37 3/10 s.

(2) Contact of 1st sunspot in northern hemisphere: 8h. 9m. 5 2/5 s.
Contact of 2nd sunspot in northern hemisphere: 8h. 10m. 47 s.

Other Facts Recorded

1. A drop of one degree in temperature during the phenomenon was noted by Mr. Guimont.

2. According to Mr. Morgan there was a perceptible darkening at 8 o'clock.

3. It was noted that at 8 o'clock chimney swifts flew out of neighbouring chimneys and circled about for ten minutes or so.

4. Sunspots took on a reddish hue in contrast to the dark surface of the moon.
5. A friend in the northern part of the city reported that she had noticed an unusual purple haze around downtown buildings during the phenomenon.

Other Notes

1. Mr. J. E. Guimont's 3-inch refractor was also used.
2. These contacts concerned the immersion phase and were timed for the centre of each spot.

C. A. C.

The Mayan Calendar—the "Venus Year"

Query

In Dr. Hogben's "Science for the Citizen" (p. 173) he refers to the accuracy of the Mayan calendar, giving a "Venus year" the value of 583.92 days. The value of Venus's orbital motion given in the HANDBOOK is 224.7 days, earth's motion 365.3, the two planets total 590 days. I assume that these Mayan calculations were based on the earth as a point of reference. Am I anywhere near right or are there other factors bearing on Mayan science?—Alexander Egenes, Paso Robles, Calif.

Answer

The Mayan people are known to have been very accurate in some of their investigations, but just wherein their calendar was more accurate than our own the present writer does not know.

No doubt the Mayans accepted the Ptolemaic theory and hence the period of Venus which they observed is what is called the *synodic* period. It is the time required by the planet to complete a revolution with respect to the sun, as seen from the earth. For example, Venus was seen at greatest elongation west of the sun on June 24, 1945. When will it be in a similar position again? We could count from an eastern elongation or from inferior or superior conjunction to the next similar one. In each case it would be a synodic revolution and the values obtained would vary among themselves slightly. The average length of the synodic periods observed over a long time gives the mean synodic period.

At present we accept the Copernican theory and are more interested in the *sidereal* period, the period of the true mechanical revolution about the sun. If one knows one of these periods and the length of the year one can easily deduce the length of the other period. The relation between them is expressed by the formula

$$\frac{1}{\text{Synodic period}} - \frac{1}{\text{Earth's period}} = \frac{1}{\text{Sidereal period}}.$$

Taking the synodic period of Venus to be 583.920 days and the tropical year to be 365.2422 days, the sidereal period is deduced to be 224.6951 days. Dr. Hogben is hardly fair to the modern astronomers.

C. A. C.

THE MOON AND THE WEATHER

The influence of the moon on the weather is an ever-recurring topic of discussion and probably will continue to be for years to come. One can only oppose this fallacy on every suitable occasion by stating ascertained facts and the hoary myth will ultimately disappear. In a recent issue of the Montreal *Star* there was printed a letter over the familiar initials "A. V. M." containing the following remarks on this subject:

Many believe that the moon has an effect on our weather simply because lunar superstitions have been handed down by ignorant people from generation to generation. In fact, it would be difficult to find a locality where such lunar superstitions are not prevalent. Nevertheless, the United States Weather Bureau, with its many years of study of weather conditions, brands as preposterous and absurd the notions that weather conditions may be foretold by the changing of the moon. I would rather believe the findings of such a recognized scientific body than accept the statements of persons quite untrained in modern experimental science.

Any qualified astronomer will tell you that moonlight is merely reflected sunlight, and that, except for small oscillations—known as "librations"—the moon always keeps the same face towards the earth. We see only that part of our side of the moon upon which the sun happens to be shining, this accounting for the so-called phases. Any astronomer, if asked, will express the opinion that the moon cannot tell us when it will be hot and when it will be cold, or when it will rain and when it will not rain. This opinion is based on the known fact that weather exists in our atmosphere and on the known fact that the sun is the only heavenly body that can affect our atmosphere.

True enough, scientists can make mistakes. They also know when they are wrong and they know how to prove that they are wrong. Scientists can also prove when they are right. I have yet to meet the person believing in astrology and the other mentioned superstitions who had sufficient training in science to recognize the real meaning of scientific proof. I have yet to meet the astrologer who could prove that he was either wrong or right, and I have yet to meet the

astrologer with sufficient knowledge of higher mathematics to enable him to work out, as does the astronomer, the positions of heavenly bodies.

I do not expect to convert "Sol" or any other astrologer—it being impossible to debate with those who ignore proven physical laws and foolish to argue with persons whose premises differ so radically from those advanced by real scientists. This, therefore, is my first and last word on the subject at this time.

C. A. C.

MEETINGS OF THE SOCIETY

AT TORONTO

October 10, 1944—The Society met at 8.00 p.m. in the McLennan Laboratory, University of Toronto; Miss R. J. Northcott in the chair.

Dr. Helen Sawyer Hogg addressed the Society on "Recent Astronomical Progress as Reported to the American Astronomical Society," referring to some highlights of the A.A.S. meeting held in Philadelphia in June. She first reviewed papers on "the astronomy of the invisible," dealing with the presence of unseen companions to nearby stars. Some time ago a star, 61 Cygni, was found to have a mass between that of the smallest star previously recognized and the largest planet in our solar system. Dr. Peter van de Kamp of Sproul Observatory reported to the A.A.S. on studies on proper motion and parallax of two stars. Barnard's star was found to oscillate over one-tenth of one second of arc in a period of 1.06 years. Mass of the unseen companion causing this oscillation was determined to be about one-sixth that of the sun. The second star studied, Lalande 21185, was found to vary its position slightly every 1.28 years and its unseen companion was computed to be about 0.13 A.U. from the main star. Whether these are stars much smaller than heretofore known, or gigantic planets, remains for the future to decide.

The percentage of known double stars is increasing and latest theories on the origin of the solar system are based on the assumption that the sun was once a double star. Of the six nearest stars, the sun is the only one that is single. Alpha Centauri is a triple system, Barnard's star is double, Wolf 359 is believed to be multiple, Lalande 21185 and Sirius are both doubles with unseen companions.

A Mexican astronomer, named Haro, reported to the A.A.S. on work at the Harvard Observatory in search of very red stars, finding many more red stars than were previously thought to exist.

Dr. J. A. Pearce of the Dominion Astrophysical Observatory, Victoria, B.C., in a paper on radial velocities of the Pleiades, told the A.A.S. of findings that the velocity of recession is about five miles a second. The stellar density in the region of the Pleiades is believed to be about 30 times that of the solar region.

Reporting on her own work on globular star clusters, Dr. Hogg told the A.A.S. of investigations at the Dunlap Observatory on the periods of variable stars in these clusters. Of 25 variables in M22 (Sagittarius), 18 were found to have periods of less than one day. Two distinct groups were found, one with periods of about one-third day and the second with periods about two-thirds of a day. There was a gap from 0.43 to 0.61 day where no periods were plotted. In other clusters all the variables have periods of about one-half day. The reason for these differences is not yet known.

Dean McLaughlin of the University of Michigan Observatory at Ann Arbor presented a paper on effects of a nova upon a nearby planet. He presented an argument to "squelch" the statement that the earth would be vaporized if the sun became a nova. Although it is exceedingly improbable that the sun might

become a nova, Dr. McLaughlin, for purposes of his paper, assumed that this could happen, and went on to show that if the sun attained a luminosity of −7 absolute magnitude, the amount of heat received by the earth would raise the temperature of the *entire* planet by only three degrees. Because the surface layers are not good conductors, most of this heat would be retained in the upper strata. If this were equal in mass to one-hundredth the total mass of the earth, the temperature of the surface layers would be raised 300°C. If this heat were mostly confined to a layer 12 km. thick, the solar outburst would raise the temperature of the earth's crust to 3500°C., the melting point of silica. For a week or two the seas would boil dry and the rocks melt, but the earth would emerge with most of its mass intact and with the continents and ocean basins pretty well unchanged. "But it would be an uncomfortable week or month," Dr. Hogg suggested. The planet Mercury, however, would be swallowed up well within the enlarged sphere of the sun.

Dr. Hogg went on to describe the evening session of the A.A.S. at the Fels Planetarium. "Certainly one of the things we must work for here is to secure a planetarium for Toronto or for Canada. It is the best way to teach people about the stars, rather than having them look *down* on celestial globes."

Mr. C. A. Crook then gave some definitions of astronomical terms, the first paper in a proposed series. At this meeting he defined conjunction, opposition, quadrature and elongation of planets.

FREDERIC L. TROYER, *Recorder.*

AT WINDSOR

Meetings December 13, 1944, to June 1945

The inaugural meeting of the Windsor Centre was held at Willistead Library on Wednesday evening, December 13, 1944, at which time the Charter of the Centre was outlined and the slate of officers was adopted. The treasurer announced that there were twenty-nine charter members of whom twenty-five were present.

The first meeting of the New Year was held January 9, 1945, with Mr. Jack Evzovitch speaking on current events. Mr. C. H. Montrose, the president, gave a most interesting talk on "Time," explaining with slides and pictures many features of the sun-dial.

The February meeting, held on February 14, showed an increasing interest in the newly-formed Society, with forty members present. Mr. C. B. Hallam in his talk on current events spoke of the wealth of information contained in the HAND BOOK of the Society. Mr. Russell Warwick chose as his topic "Additional Aids to the Astronomer."

The March meeting of the Society took place on Tuesday evening, March 13, at which time the president introduced Mr. Charles Bell, who covered the events which would be of interest to the astronomer during the spring and summer months. The second speaker on the programme was Dr. A. T. Knight who spoke on "Solar Eruptions." The topic was well handled by Dr. Knight, who is well informed on this subject.

On Saturday evening, April 7, the Windsor Centre enjoyed a most outstanding meeting. It was outstanding for two reasons, in that it was the first time that an outside speaker had addressed the Society, and second, that the speaker was Miss Elizabeth Achelis of New York, President of the World Calendar Association. Her talk as given to the Society has been published in its entirety in the July-August issue of the JOURNAL. A goodly number was present and many enjoyed the privilege of meeting the lady in person after the lecture.

The attendance at the meeting of May 16 was hampered by the elements but those who turned out were amply rewarded by a most interesting lecture entitled "Inside the Stars" given by Mr. W. Almon Hare, as well as Mr. Lorne Rogers' talk on current events.

For the June meeting the members were entertained at the summer home of the secretary. Mr. C. B. Hallam in discussing current events dealt mainly with the eclipse of July 9, 1945. There were twelve guests from Detroit, six of whom planned to make the journey to view the total eclipse. Mr. Hugh Murray was also featured on the programme. Telescopic observation was fair and enjoyed by several. Refreshments were served at the close of the meeting.

Six regular meetings and three executive meetings have been held so far this year. It has been our custom to encourage the attendance of senior year pupils of the various collegiate institutes at the meetings and several have shown considerable interest.

D. C. BAWTENHEIMER, *Secretary.*

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(Continued at bottom of next page)

THE ROYAL ASTRONOMICAL SOCIETY OF CANADA
1890-1945

The Society was incorporated in 1890 under the name of The Astronomical and Physical Society of Toronto, and assumed its present name in 1903.

For many years the Toronto organization existed alone, but now the Society is national in extent, having active Centres in Montreal and Quebec, P.Q.; Ottawa, Toronto, Hamilton, London and Windsor, Ontario; Winnipeg, Man.; Edmonton, Alta.; Vancouver and Victoria, B.C. As well as about 950 members of these Canadian Centres, there are over 200 members not attached to any Centre, mostly resident in other nations, while some 300 additional institutions or persons are on the regular mailing list for our publications.

The Society publishes a monthly "Journal" containing about 500 pages and a yearly "Observer's Handbook" of 80 pages. Single copies of the "Journal" or "Handbook" are 25 cents, postpaid. In quantities of 10 or more copies, the price is 20 cents a copy.

Membership is open to anyone interested in astronomy. Annual dues, $2.00; life membership, $25.00. Publications are sent free to all members or may be subscribed for separately. Applications for membership or publications may be made to the General Secretary, 198 College St., Toronto.

The Society has for Sale:

Reprinted from the "Journal" of the Royal Astronomical Society, 1936-1944.

The Physical State of the Upper Atmosphere, (revised 1941) by B. Haurwitz, 96 pages; Price 75 cents postpaid.

General Instruction for Meteor Observing, (revised 1940) by Peter M. Millman, 24 pages; Price 15 cents postpaid.

The Visual Photometry of Variable Stars, by H. Boyd Brydon, 64 pages; Price 50 cents postpaid.

A Yoke Mounting for the Six-inch Telescope, by H. Boyd Brydon, 8 pages; Price 10 cents postpaid.

Setting Up and Adjusting the Equatorial Reflecting Telescope, by H. Boyd Brydon, 25 pages; Price 25 cents postpaid.

Occultations: their Prediction, Observation and Reduction, by H. Boyd Brydon, 76 pages, 1944; Price 60 cents.

In quantities of ten or more copies, a discount of 20 per cent will be allowed. Send Money Order to 198 College St., Toronto.

(*Continued from previous page*)

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